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THE ENERGY CONTENT OF THE DIET¹

PROTEINS IN GROWTH

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A N eminent biochemist said recently to a friend of mine: "The time is coming when you will give a grocery order in this fashion: 'Send to 3405 South Street 1,500 calories of eatables, $\frac{1}{4}$ protein and the rest half carbohydrate and half fat, the whole to cost fifty cents.' " It seems to put considerable responsibility on the grocer. One wonders if the time may not come when a doctor will say to a dietitian, "Plan a two weeks' dietary for that sick boy in room 101 in which the protein shall contain 2 per cent. tryptophan, 5 per cent. tyrosin, 15 per cent. glyco-coll," etc. The rôle of proteins in growth is fast becoming the rôle of amino acids and a difficult time is ahead of the dietitian. The accumulation of facts fills full the lives of one group of people; gathering and correlating the facts as they accumulate is enough to fill the lives of another group; and the practical application is far more than enough for another group. The groups are not in sufficiently close contact.

The body uses amino acids, but it must be fed proteins, and the amino acids it receives depend in amount at least not only upon the chemical composition of the protein, but upon its physical character and upon the other substances combined or mixed with it in the food. There has long been evidence that the proportion of ingested protein that is digested and absorbed from bread varies with the amount of grain cortex present, less being absorbed from the coarser varieties; that it varies in other foods with the amount of cellulose present. The much-discussed inadequacy of corn to serve as an exclusive ration, long thought to be due to the character of its proteins, has been shown by Hart and McCollum² to lie in its mineral content. When this is corrected, normal growth is possible on a corn ration. This, of course, is rather a misinterpretation than an actual modification of the utilization of the protein. Similarly, the apparent inability of some babies to utilize milk proteins is not unfrequently due to an excess of fat or of carbohydrate in the food. When this is remedied, the symptoms of protein indigestion disappear. We have found recently that the digestion of milk proteins is distinctly and

¹ Papers presented at the symposium before the Section of Physiology and Experimental Medicine of the American Association for the Advancement of Science, Columbus, December, 1915.

² "The Influence on Growth of Rations Restricted to the Corn or Wheat Grain," *J. Biol. Chem.*, 19, 373-97, 1914.

differently modified by the various carbohydrates commonly used in milk modification for babies.

In order, then, to consider the rôle of proteins in growth from the standpoint of the sources of our food supply, it is necessary to consider (1) the utilization of proteins, dependent on those characteristics of the proteins themselves or of the foods containing them, which make them resistant or not to the digestive enzymes or which influence the rate of their passage through the alimentary tract; (2) their assimilation; to what extent they can supply the essential amino acids in the proportion in which the body can use them for tissue building; and (3) the physiological effect of individual amino acids, especially, perhaps, those furnished by the proteins in question in excess of the body's needs.

The experiments of Mendel and Fine,² and more recently a shorter series by Howe and Hawk,³ show that when fed in a more or less isolated form, the proteins of cereals are as completely digested and absorbed as are the proteins of meat—91–97 per cent.; but for the proteins fed in the natural foods these values do not hold. Only 80–85 per cent. of the nitrogen of wheat bread is absorbed, 70 per cent. of rye, 58 per cent. pumpernickel, 40.76 per cent. barley and 61–82 per cent. of corn nitrogen. These values for the whole grains were determined a good while ago by methods less accurate than those now in use, but they are at least comparable among themselves and they show, undoubtedly, lower protein utilization in grains than in isolated grain proteins.

This loss must be considered in planning the dietaries of young children, especially of those who can not take much milk. The proteins of cereals are as well utilized as milk proteins if they are fed in isolated form, but as long as dietaries contain not gliadin and glutenin and maize glutelin, but cream of wheat and hominy, we must count on a loss of 20–40 per cent. of the protein, if the data at present available represent facts. The proportion of the protein intake that comes from cereals is far from negligible in many children's dietaries, and it is unwise to get too close to the minimum protein requirements, especially as we do not know exactly what this minimum is. Hindhede's⁴ surprisingly successful maintenance of body weight and good nutritive condition on an exclusive diet of potatoes and fat would indicate a high utilization of potato proteins.

With equal digestion and absorption, proteins may still differ greatly in their suitability for tissue construction and otherwise in their physiological effect. It has been found that 20 per cent. of the nitrogen absorbed from ingested zein is promptly excreted in the urine; over 40 per

² "Utilization of the Proteins of Wheat," *J. Biol. Chem.*, 10, 303, 1912; "of Barley," *ibid.*, p. 339; "of Corn," *ibid.*, p. 345.

³ "Utilization of Individual Proteins as Influenced by Repeated Fasting," Eighth International Congress of Applied Chemistry, 19, 145.

⁴ "Studies on the Protein Minimum," *Skand. Arch. Physiol.*, 30, 97–182.

cent. of gelatin nitrogen. Howe and Hawk found that the proteins of meat and of the commercial wheat preparation gliadin are equally well digested and absorbed, but when fed five days in equal quantity and in similar rations, gliadin gave a negative nitrogen balance of 1.3 g., while meat gave a positive balance of 11.3 g. A large number of proteins have been shown by Osborne and Mendel and others to contain all the amino acids necessary for growth: ovo-albumin, ovo-vitellin, glutenin, maize glutelin, edestin, casein, lactalbumin.

Several natural mixtures of proteins such as those occurring in wheat, corn, oats, milk, respectively, have been studied, largely by Hart, McCollum⁵ and their co-workers, and have been found to furnish the amino acids necessary for tissue construction. McCollum⁶ has compared the protein mixtures in these grains with one another and with the protein mixture of milk as to their availability for growth. Of the nitrogen of cereals 23–24 per cent. is available, 45 per cent. casein nitrogen and 63 per cent. of milk protein nitrogen fed as milk. Evidently, the amino acids resulting from the digestion of milk proteins not only contain all the units necessary for tissue building, but contain them more nearly in the proportion in which they can be used than is the case with the other foods considered. If there is a shortage of one amino acid essential to the building of a body protein, the amount of that acid present determines not only the amount of tissue construction, the rate of growth, but determines also the proportion of the food protein that can be used for growth. The body can store very little reserve amino acid—nearly all that can not be built into protein is promptly deaminized and the nitrogen excreted.

These facts are also shown in a different way in recent experiments of Osborne and Mendel.⁷ The growth of rats on 18 per cent. casein food was normal, on 12 per cent. casein food subnormal, but the addition of a small amount of cystin to the latter ration made it equal to the 18-per-cent. casein food in growth production. The utilization of the whole protein for growth was increased by an increase in the amount of the needed unit. Similar results were obtained by adding lysin to edestin.

These and similar investigations have thrown light on the nutritive value of individual amino acids: the aromatic amino acids are essential to maintenance; cystin, lysin, probably arginin and histidine, are essential to growth. Evvard suggests that cystin may be responsible for the darker and thicker hair of pigs whose mothers received rations rich in cystin during pregnancy; Lusk⁸ in his study of the specific dynamic

⁵ "Influence on Growth of Rations Restricted to the Corn or Wheat Grain," *J. Biol. Chem.*, 19, 373–97, 1914.

⁶ "Value of the Cereal Grains and of Milk for Growth," *ibid.*, p. 323–35.

⁷ "Comparative Nutritive Value of Certain Proteins in Growth," *J. Biol. Chem.*, 20, 351–78, 1915.

⁸ "Investigation into the Specific Dynamic Action of the Foodstuffs," *J. Biol. Chem.*, 20, 555–618, 1915.

action of food stuffs, finds that glycocoll has a specific dynamic action of 100, alanin of 50.

Many of these results of nutrition studies can not be used with confidence in problems of human nutrition until more is known about the differences in the amino acid content of the flesh of different species. The pig can use 23 per cent. of wheat proteins for growth, but we can not yet be sure that this is true of the child; and so of many of the other very interesting and valuable contributions cited. They suggest wonderful possibilities—future possibilities—for the dietitian: a child who is undersized and frail can sometime be fed just the right combination of milk, eggs and cereals to furnish the amino acids he needs in the right proportion with no large excess of any one to overtax the excretory system or to overstimulate metabolism; a worn-out neurasthenic can be given just the right amino acids to replace worn-out tissue and enough glycocoll to stimulate metabolism—in gelatin perhaps. We have some slight clinical evidence that this last works out.

THE MINERAL NUTRIENTS IN PRACTICAL HUMAN DIETETICS

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IN consenting to present this paper I did so with the feeling that perhaps I have as good right as any one else to confess for all of us that we know very little about the subject. The suggestions I have to make then are offered in entire humility and with satisfaction only that we are on the road to more complete understanding.

My task is to point out the bearings of results of experiments in the field of mineral metabolism upon our irrational, uncontrolled and largely uncontrollable human dietetic affairs. Only in the case of infants, invalids, lunatics and convicts does it seem practicable to regulate the diet of human beings with the same rationality and particularity with which the successful live-stock farmer habitually feeds his animals. In spite of the difficulties of the task, however, and the indifference of most of us to the economic and rational aspects of our own eating, there are those dependent upon us who should have the benefit of our wisest counsel, even though we put ourselves in the position of saying, "you are to do not as I do but as I say."

In order to bring clearly to mind the basic principles of nutrition involved in this consideration I must enumerate the functions of the mineral elements in animal metabolism:

As bearers of electricity the mineral elements dominate the whole course of metabolism.